Dietary Means to Reduce the Contributions of Pigs to Environmental Pollution

C.F.M. de Lange, Ph.D., Dept. of Animal and Poultry Science, University of Guelph

(From Proceedings of Swine Production and the Environment Seminar "Living With Your Neighbours", March 26, 1997, Shakespeare, Ontario)

In areas with intensive swine production, pigs can contribute to environmental pollution. Environmental pollution is the result of odours released from swine facilities and the disposal of nutrients with pig manure. In this short paper, odours will be discussed very briefly. The major emphasis is on manipulating the pigs' diet to reduce the excretion of nutrients in pig manure. Nutrients that are of prime concern in regards to environmental pollution are copper, zinc, nitrogen (an important component of protein and amino acids) and phosphorus.

Odour

Odours are the result of volatile "smelly" compounds that pigs excrete with manure and/or that are released from pig manure during storage. Ammonia (NH_3) and hydrogen sulfate (H_2S) are two compounds that are known to contribute to "pig smell". The production of these two compounds can be influenced by manipulating the pigs' diet. For example, the production of ammonia is closely related to the excretion of nitrogen with pig manure (see below). However, the production of these compounds is much better controlled by the treatment and management of pig manure (i.e. reducing the effective manuring area in the pen from which these compounds can evaporate; use partly, rather than completely, slatted floors; have wider gaps over the manure pits along the pen partitions so that manure will not build up in these areas; cooling the manure quickly by removing it from the pig barn; aeration of pig manure, possibly the use of additives to manipulate microbial fermentation etc.). It should be noted that many other compounds contribute to pig odour. Again, factors that cause, and that can be used to reduce, the production of these compounds are more likely associated with manure handling and storage than with manipulating diet composition.

Copper and Zinc

The levels of copper and zinc in pig diets are generally much higher than the minimum levels that pigs require for normal performance (i.e. 5-25 ppm copper and 50 to 125 ppm zinc for the various classes of swine). This is because copper and zinc, when included at levels much higher than the "minimum requirements", have growth promoting properties. However, the growth promoting effects of high copper and zinc levels are dependent on the level and types of disease in the pig unit. The value of high copper and zinc levels are smaller in clean, healthy pigs. In some countries, such as The Netherlands, growth promoting levels of copper and zinc are simply no longer allowed in finisher pig diets. At "minimum requirement" levels, the excretion of copper and zinc with pig manure is no longer a concern; nitrogen and phosphorus excretion are then the main issues.

Nitrogen and Phosphorus Balances

In Table 1 the nitrogen (N), and phosphorus (P) balance for "average" grower-finisher pigs that are fed "average" diets are summarized. As indicated, about two thirds of nitrogen and phosphorus intake is excreted with manure. These values are slightly lower in starter pigs and higher in sows. Since most of the manure on a typical farrow to finish operation is produced by grower-finisher pigs, "average" farm values will be similar to the values given for grower-finisher pigs. Given this low efficiency there is room for reducing N and P excretion through improving the efficiency with which they are retained in the pig.

Table 1. Typical nitrogen and phosphorus balances in grower-finisher pigs (25 to 106 kg body weight; Jongbloed, 1991).

	Nitrogen (N)	Phosphorus (P)
Dietary level (%)	16.7*	0.52
Intake (kg/pig)	6.36	1.23
Retention (kg/pig)	1.88	0.40
Excretion (kg/pig)	4.48	0.83
Excretion (% of intake)	71.5	67.5

* Crude protein (Nx6.25) rather than N levels

Two MAIN Means to Improve the Efficiency of P Utilization in (Grower-Finisher) Pigs.

1. Improving P digestibilities in pig feed ingredients.

The major reason for the inefficiency of P utilization is the poor digestibility/availability of P that is present in plant products (i.e. 15% in corn, 28% in soybean meal). This is because P in plant products is included in complex structures, called phytates, that are poorly utilized by pigs. In contrast, the availability of P in inorganic sources (di- and mono-calcium phosphate) is much higher (70 to 90%). For this very simple reason pig diets should be formulated on an available rather than a total P basis. Some plant products, in particular wheat products, contain some natural enzymes (phytases) that can liberate P from these phytates and that contribute to improvements in P availability in these ingredients.

Over the last few years, "synthetic" phytases have become available. These products are routinely included in pig and poultry diets in countries, such as The Netherlands. When these phytases are properly used they can improve P digestibility (Table 2). As a result the total P levels in the diet can be reduced, the efficiency with which phosphorus is retained in the animal is improved, and the excretion with P into the environment is reduced.

Table 2. Effect of added phytase on phosphorus digestibility in growing pigs fed corn-soybean meal based diets (Simons et al., 1990).

	Control	Control + 1000 phytase units/kg
Total P (g/kg diet)	3.3	3.3
P digestibility (%)	20	46
Digestible P (g/kg diet)	66	1.52

When including phytases in pig diets, various points should be considered:

- Different commercial products differ in the content of active phytase. Phytase units (PTU) may be used to compare different products using a standardized test.
- Phytases are quite unstable when exposed to heat. During pelleting the temperature of the feed should not exceed 70-75oC when phytases are

101-05314/

included. Phytase activity should be checked in the complete, processed feed.

- Phytases not only increase the digestibility of P; they also increase the digestibility of calcium (Ca) and other trace minerals that are tied to the phytate complex (Cu, Zn, etc.). Some recent studies from Europe also suggest that phytase can improve feed utilization (by 1-2%) in starter and grower pigs by making other nutrients more available as well. This results in additional "value" of added phytase.
- When determining the value of phytase the effects of reducing the P and Ca levels in the diet should be considered. In particular, in high energy diets in which (expensive) fat is used, a reduction in mineral levels will be associated with a reduced need to use fat, as there is more "space" in the feed formula. This results in reductions in ingredient costs.
- There is still some debate on how much phytase should be included in practical diets and by how much the (available) P levels in the diets can be reduced. The value of phytase is larger at low levels (less than 200 PTU/kg of feed: .2 g extra dig. P/ kg of feed per 100 PTU) than at intermediate levels (200 to 1000 PTU/kg of feed: .13 g extra dig. P / kg of feed per 100 PTU). At high levels (more than 1000 PTU), improvements in P digestibility are minimal. Furthermore, there is still some debate about the effect of pig age/weight on the response to phytase (it may be better than the indicated values at higher body weights) and on the effects of phytase in different diets (i.e. diets with different ingredient compositions). Finally, the effectiveness of phytase is affected by the calcium to phosphorus level in the diet; these should be maintained low (1 to 1.2 Ca:total P)

Given the above considerations and given today's prices of phytase and inorganic P sources, the use of phytase does not appear to increase feed cost: the cost of the product is largely offset by the reduced need for P and Ca in the feed (personal communication Jim Parr, BASF, 1997).

2. Feed more closely to the pigs' requirements

The actual P (and other nutrient) levels in diets are often higher than levels that are actually required by pigs. These "safety" margins are sometimes very large. Reasons for these (large) safety margins (and means to reduce these) include:

- To account for potential errors in feed preparation and delivery (calibrate your mixing equipment; sample and analyze ingredients and some of the prepared diets).
- Only a few diets are used to meet the nutrient requirements of a wide range of pigs (apply phase and split-sex feeding).
- The Ca to P ratio in the diet is too high (keep it around 1.2).
- Higher P (and Ca) levels are required for breeding stock than for market pigs (keep and manage breeding stock different from market hogs)
- The perceived requirements of some groups of pigs, with high performance potentials, are higher than the actual requirements (use common sense; follow published guidelines; use a factorial approach to estimate the P requirements for different groups of pigs).

In the Netherlands, the available P allowances for the various classes of swine are 0.41% for starter pigs, 0.25% for grower pigs, 0.20% for finisher pigs, 0.25% for dry sows and .36% for nursing sows. In particular, the available P levels for the finisher pigs and dry sows are lower than these in practical diets in Ontario. A reduction in available P allowances will reduce the excretion of P with swine manure and reduce feed costs. A reduction in P intake by 10% will reduce P excretion with manure by at least 15%.

Two MAIN Means to Improve the Efficiency of N Utilization in (Grower-Finisher) Pigs.

1. Improve the dietary amino acid balance

The balance in which amino acids are supplied in the diet differs substantially from the balance in which they are required for optimum performance by the various classes of swine. In typical corn and soybean meal based diets fed to grower pigs, about 25% of the ingested protein is supplied by "unbalanced" amino acids. These amino acids are of no use to pigs for building body protein and thus lean meat. They are degraded, are used as an (expensive) source of energy, and contribute to N excretion with urine. Just under half of N excretion in pig manure can be attributed to the poor amino acid balance in the pigs' diet (Table 1). Furthermore, in a recent experiment that we conducted at the University of Guelph, we were able to reduce N excretion in growing pigs by close to 40% by manipulating the dietary amino acid balance (Tuitoek et al., 1997).

A simple means to improve the dietary amino acid balance is to replace some of the standard protein sources (e.g. soybean meal) with purified synthetic amino acids (lysine.HCl containing 79% lysine, threonine, methionine, tryptophan). If these diets are properly formulated and produced, they should support at least the same levels of performance as compared to corn soybean meal based diets (Tuitoek et al, 1997). In Table 3 potential reductions in N excretion are presented when diets are fed that differ in protein levels but that are balanced for amino acids. The estimated costs of these diets are give as well. If some of the soybean meal is replaced with lysine.HCl, both feed cost and the excretion of N with pig manure are reduced! But there is a (large) cost associated with large reductions in dietary protein levels. Given the current prices of synthetic amino acids, it does not make economic sense to include synthetic amino acids other than lysine.HCl in grower pig diets. This will change when the availability and price of tryptophan will improve.

Table 3. Estimated cost of corn and soybean meal based grower-finisher diets with varying protein levels but balanced for amino acids using synthetic amino acids. The estimated reduction in N excretion with manure as compared to the "standard" corn soybean meal based diet is given as well.

	Corn-SBM-pmx	+ Lysine	+ Lysine+ Threonine+ Tryptophan
Ingredient comp. (%)			
Corn	75.85	79.38	83.28
Soybean meal	21.15	17.50	13.40
Premix	3.00	3.00	3.00
Lysine.HCl	--	0.12	0.25
Threonine	--	--	0.06
Tryptophan	--	--	0.02
Calculated content (%)			
Total protein	16.5	15.2	13.7
Dig. Lysine	**.70***	.70	.70
Dig. Threonine	.46	.42	.42
Dig. Tryptophan	.14	.12	.12
Dig. Methionine	.24	.22	.21
Dig. Met + Cys	.47	.44	.41
Ingredient cost ($/tonne)	220.6	218.7	239.1
Reduction in N excretion (%)#		-11%	-24%

* values that are printed in bold are levels that are first or equally limiting in the

diet.

% reduction as compared to feeding the corn-SBM-premix diet without any added synthetic amino acids.

Some additional comments:

- There are two additional benefits of reducing the total protein levels in pig diets: 1) excessive protein intake may induce scours, in particular in young pigs, and 2) there is a metabolic cost (and body heat production) associated with excreting N in urine; in young pigs and pigs under heat stress feed intake and performance will be slightly improved when low protein diets are fed that are properly balanced with amino acids.
- Synthetic amino acids supply energy. This should be considered in (least) cost feed formulation.
- There is still some debate about the optimum amino acid balance over the various body weight ranges. In recent studies in Guelph, we were unable to reduce protein levels (and
- N excretion with manure) in the finisher diet to the same degree as that in the grower diet.
- Some of the benefits of using synthetic amino acids also apply to other protein sources with a good amino acid balance (fish meals, meat meals, etc.).Feed more closely to the pigs' requirements

2. Feed more closely to the pigs' requirements

Just like for P, lysine (generally the first limiting amino acid) levels in diets are often higher than levels that are actually required by pigs. These "safety" margins are sometimes very large and expensive. If we stick to some important principles (quality control on ingredients, feed preparation and delivery; feeding according to lean growth potentials; phase and split-sex feeding; minimize feed wastage; maintain a good health status) both feeding cost and the excretion of N with pig manure can be reduced. Some examples:

• A reduction in diet Crude Protein (CP) levels by 10% will reduce N excretion with manure by at least 15%.

• Improving lean growth potentials as a result of feeding entire males rather than barrows (an improvement of about 15%) will reduce N (and P) excretion in manure by about 15%.

• N excretion will be reduced by about 15% when a 16% CP grower diet is replaced by a 14% CP finisher diet at 60 kg body weight.

• In a low disease herd (SPF) N excretion with manure will be about 10% less than in a herd with a conventional health status.

Conclusions and Two Final Notes

- Reductions in odour released from swine facilities is better achieved through altering manure management than through manipulating the pigs' diets.
- Potential copper and zinc pollution can be eliminated if copper and zinc are no longer allowed at growth promoting levels in pig diets, in particular in finisher pig diets.
- Serious consideration should be given to the use of phytase to enhance P digestibility in pig feed ingredients of plant origin. This will substantially reduce P excretion with pig manure. The value of phytase is largely determined by its cost relative to the cost of inorganic P sources such as

dicalcium-phosphate.

- Synthetic amino acids may be used to substantially reduce N excretion with pig manure. The value of synthetic amino acids is largely determined by their costs relative to the cost of conventional protein sources.
- Feeding pigs more closely to their actual requirements will improve profitability in commercial pork production AND reduce the potential contribution of pigs to environmental pollution.

Two final notes:

1. In southwestern Ontario we still have a large land basis associated with pig production. If handled properly, and if we maintain an appropriate balance between the size of swine herds and the amounts of land available for manure spreading, pig manure is a resource, NOT a burden. Pig manure is an important source of nutrients and organic material. The latter can not be provided by synthetic, inorganic fertilizer. If we run into problems with pig manure and environmental pollution, we have nobody but ourselves to blame!.

2. An important contributor to the cost of manure storage and handling is the amount of water that ends up in the manure pits. Through proper management of drinkers (type, placing, flow rates) and managing water usage for cleaning, the manure volume can be reduced substantially.

References

A complete listing of the references is available upon request from the author.

Acknowledgments

Information provided by Jim Parr (BASF Canada Inc.) and Theo Kissler (Halchemix Canada inc.) is gratefully acknowledged.

| Top of Page |

| Livestock Home Page |

| Central Site | Feedback | Search | Site Map | Français |
| Home | What's New | Calendar | Products | News Releases |

Ontario
This site maintained by the Government of Ontario, Canada

This information is provided as a public service, but we cannot guarantee that the information is current or accurate.
Readers should verify the information before acting on it.

Feedback and technical inquiries to: livestock@omafra.gov.on.ca
© Copyright 2001 Queen's Printer for Ontario
Last Updated: January 29, 2001